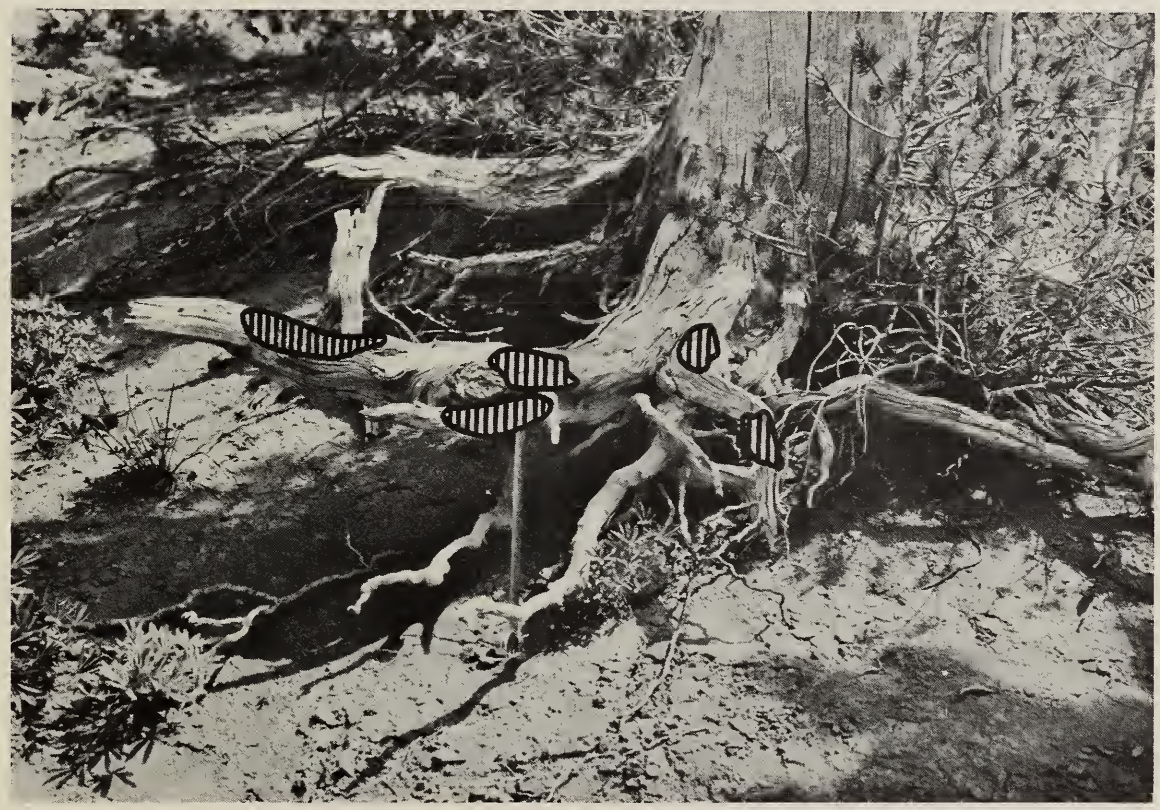
WATERSHED & RANGE CONDITIONS ON BIG GAME RIDGE & VICINITY

TETON NATIONAL FOREST, WYOMING



by

A. Russell Croft - National Forest Administration.

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FOREST SERVICE,

U. S. DEPARTMENT OF AGRICULTURE,

OGDEN, UTAH.

Oct. 1960.

FOREWORD

Since about 1876 the large elk populations in and around Jackson Hole, Wyoming, have been the subject of considerable study and widespread popular concern. This concern has given rise to campaigns to "Save the Elk" from the ravages of those who would subject them to unnecessary slaughter and from the encroachment of man on the animal's habitat, particularly their winter feeding grounds.

More recently a third enemy--a more insidious one--has appeared in the form of damage--and in some cases destruction--of the soil and vegetation on the high mountain range-watersheds which supply most of the elk's spring, summer, and fall feed.

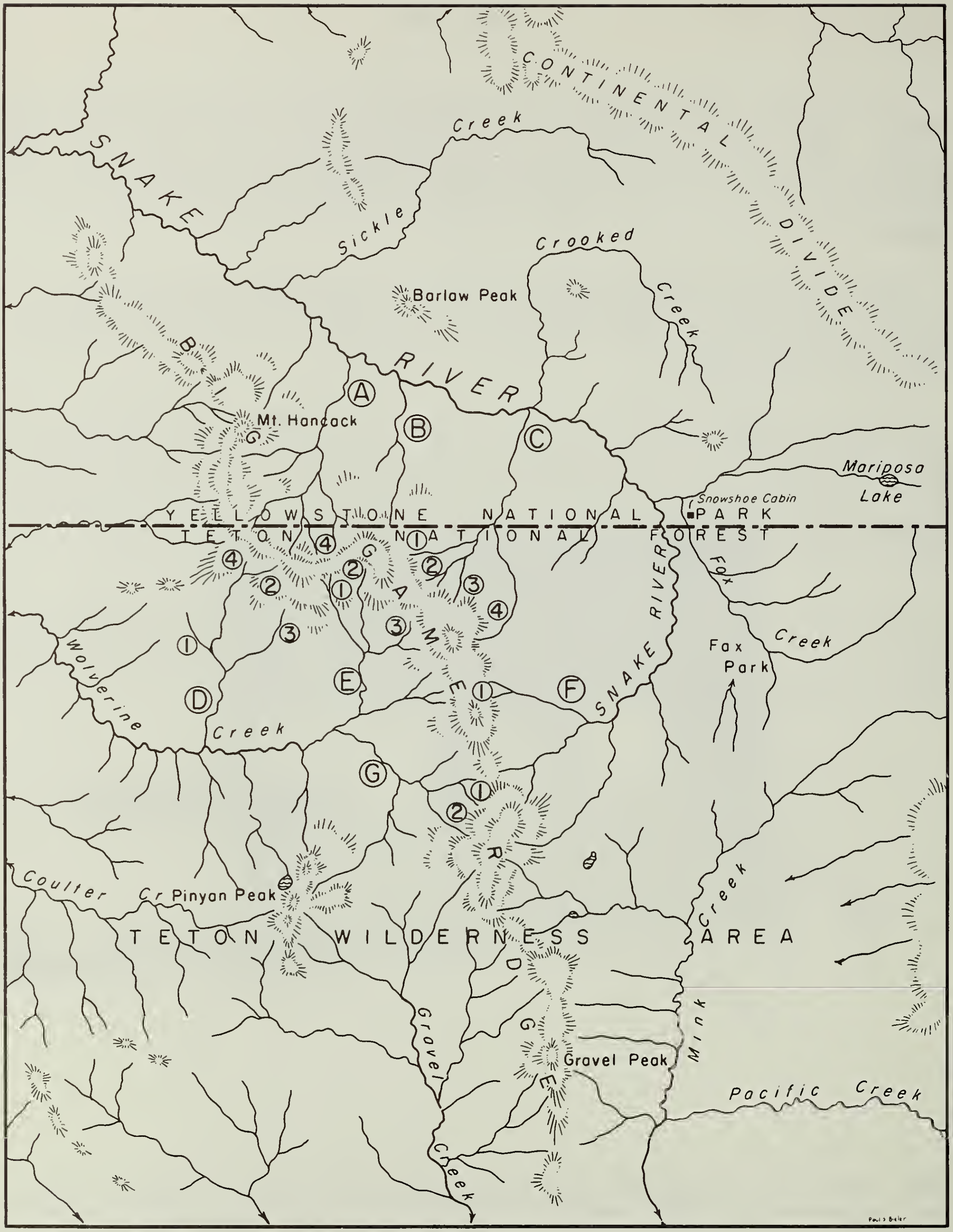
Damage to these vital resources that has resulted in low productivity of forage--and in some cases no productivity at all--cannot long continue without serious consequences. The problem is real and vital. It has many aspects that reach far beyond the welfare of the animals themselves because erosion of watershed soil also affects water quality, streamflow characteristics, fish habitat, aesthetic values, and the economy of local communities.

The problem calls for statesmanlike action by all those interested in the welfare of the elk and the range and watersheds on which they depend. A program of management that will assure perpetuity of the elk and the related soil and forage resources is urgently needed.

Floyd Iverson
Regional Forester

Reed W. Bailey
Director

COVER: Remains of a limber pine tree on Big Game Ridge probably killed by fire. Age-studies (1955) made of average size trees that came in after the burn established the age of the oldest trees at about 70 years which suggests the fire occurred about 1885. Only spots on the upper part of the roots have been burned (crosshatched) which suggests that most of the roots now exposed were covered with soil when the fire occurred.



BIG GAME RIDGE AND VICINITY

TETON NATIONAL FOREST

YELLOWSTONE NATIONAL PARK

SCALE

Scale 0 1 2 3 4 5 Miles

Source USGS Lake Quadrangle, Wyoming

OBSERVATIONS ON WATERSHED AND RANGE CONDITIONS ON BIG GAME RIDGE AND VICINITY, TETON NATIONAL FOREST, WYOMING

By

A. R. Croft and Lincoln Ellison*

In 1954, Regional Forester C. J. Olsen requested the writers to examine watershed and range conditions on part of Big Game Ridge, Teton Wilderness Area, Teton National Forest. The four objectives of this study were to ascertain: (1) to what extent plant cover had been depleted, (2) to what extent soil erosion had been accelerated in excess of normal geologic rate, (3) the causes of plant or soil deterioration that may have taken place, and (4) to recommend measures necessary to correct any unsatisfactory conditions indicated by the study.

This report covers observations made August 18 to 23, 1955, inclusive, in company with the following men:

Lowell Adam	Wildlife Research Biologist, U.S. Fish and Wildlife Service, Missoula, Montana
Chester A. Anderson	Wildlife Biologist, Wyoming State Department of Game and Fish
John W. Deinema	Ranger, Buffalo District, Teton National Forest
David M. Gaufin	Assistant Supervisor, Teton National Forest (August 21-23)
Robert L. Patterson	Pittman-Robertson Coordinator, Wyoming State Department of Game and Fish
Robert L. Safran	Ranger, Gros Ventre District, Teton National Forest

On August 18 we rode up Pacific Creek and Gravel Creek to Fox Park. We camped at Fox Park, near the junction of Fox Creek and the Snake River, on the boundary of Yellowstone National Park, and made this our base camp.

On August 19, we rode into the head of the South Fork of Wolverine Creek, (G-1 and 2)** across part of Big Game Ridge and back to Fox Park. We observed eroded soil that had been denuded of protective plant and litter cover in the small headwater basins which caused local flood deposits along the

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*Forester, National Forest Administration and Ecologist, Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, Utah. (This report was in rough draft form at the time of Dr. Ellison's untimely death. Except for minor changes, this final draft reports the same observations and conclusions as the original.)

**Letters and numbers refer to drainages without names shown on the map.

trail across the head of the South Fork of Wolverine Creek. We observed similar deterioration of plants and topsoil on Big Game Ridge, which caused flood deposits in a Snake River tributary (F), which empties below the Dietrich Camp. Above this point is a remarkably stable stream with heavily sodded banks and with stream gravel covered by blue-black crustose lichens that mask the nature of the parent rock. Lichens cannot exist on the stream gravels if even a small amount of sediment is carried in the water, because the sediment polishes rocks clean.

On August 20 we rode northwest along Big Game Ridge into a Snake River tributary that heads south of Yellowstone National Park (A-4), and back up the Snake River to Fox Park. We observed damaged vegetation and topsoil on that part of Big Game Ridge draining into Wolverine Creek (E-1) and in a Snake River tributary (A-4), that led to gullying of the channel and flood deposits in the lower reaches of that tributary and in the Snake River.

On August 22 we rode again on Big Game Ridge along the boundary of Yellowstone National Park to a point south of Hancock Peak, and returned by the same route to Fox Park. The purpose of this trip was to observe indicators of range condition and trend in greater detail than had been possible August 20.

Figure 1.--View of the south end of Big Game Ridge from the head of Wolverine Creek (foreground). The open savanna-type terrain probably loses its snow earlier in the spring than the patchy timber, and therefore is grazed by elk relatively early each spring.

Figure 2.--This view from the ridgetop of Snake River tributary C-2, in the immediate vicinity of the proposed elk exclosures, shows the general characteristics of Wolverine tributaries E-1, 2 and 3.

On August 23 we rode up to Big Game Ridge, down the North Fork of Wolverine Creek (D-3), out the head of Wolverine Creek, and down Gravel and Pacific Creeks.

We had the alternatives of making general observations on several problem areas, or of concentrating our observations on one specific area, and we chose the latter.

NATURE OF COUNTRY

The section of Big Game Ridge that we examined runs from southeast to northwest into Yellowstone National Park (figs. 1 and 2). Although steep slopes occur, the general topography is gentle rather than rugged, with broad ridges, moderate slopes, and alluvium-filled valleys. The elevation of Big Game Ridge varies from about 9,500 to 9,800 feet, but Mt. Hancock is 10,150 feet high. The elevation of the Fox Park snowshoe cabin is about 8,300 feet. (Elevations obtained from topographic map.)

The upper slopes of Big Game Ridge are open and subalpine in aspect, with patches of limber pine. Most of the country lying below the open ridge is forested with limber pine and alpine fir at higher elevations and with lodgepole pine and alpine fir at lower elevations. Lowlands like Fox Park are broad meadows relatively poorly drained and densely covered with herbaceous vegetation (fig. 3).

Figure 3.--View upstream in Snake River drainage, Teton Wilderness Area, about 3/4 mile west of Snowshoe Cabin No. 229, in Yellowstone Park. Meadows such as this usually show very good stands of grass, sedge, and some forbs, with a light mixture of shrubs. Generally there is very little bare ground and soil is very stable.

Big Game Ridge is composed primarily of sedimentary rocks, mostly soft sandstones which evidently weather readily to sand. The soils of the valleys, adjacent slopes, and knolls are derived from alluvial materials.

DETERIORATION OF SUBALPINE VEGETATION AND SOIL

The evidence of depleted vegetation and accelerated soil erosion, both on Big Game Ridge and the surrounding country, is both familiar and impressive --familiar because the same signs one finds on overgrazed and damaged livestock range in Montana, Idaho, Wyoming, Utah, Nevada, and other states are repeated here, and impressive because no domestic livestock range the writers have ever seen has been more severely or extensively deteriorated (figs. 4 and 5). The evidences of damage may be summarized as follows:

Figure 4.--Seriously depleted vegetation and bare subsoil at the head of Wolverine tributary E-1.

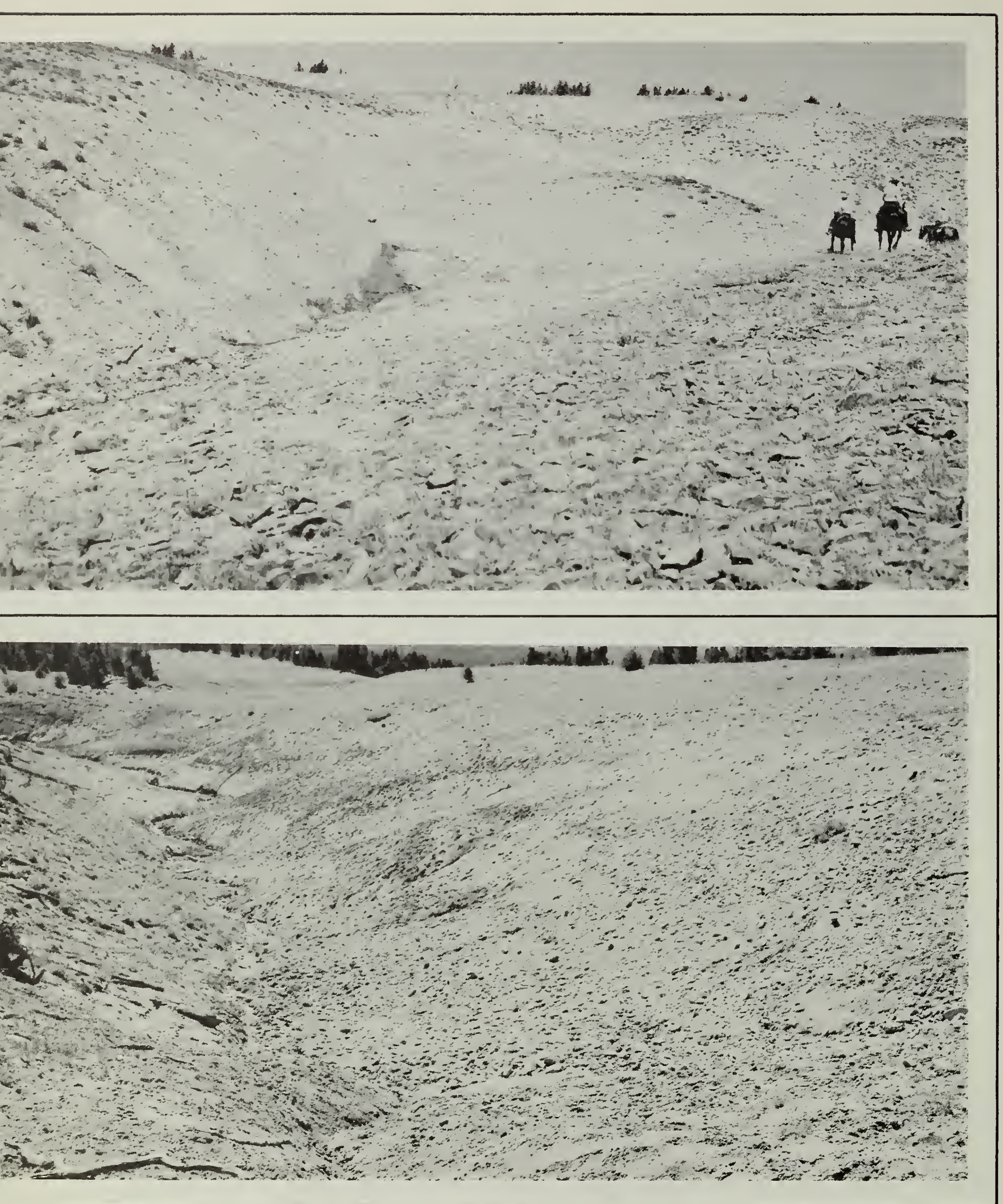

Figure 5.--Bare eroded soil on Big Game Ridge about 1/4 mile south of the south boundary of Yellowstone National Park in Snake River tributary, C-1.

Plant Cover

On some areas along Big Game Ridge the weathered sandstone soil material is as bare of vegetation as it is possible to be on areas of several square yards (fig. 6). These areas are obviously almost as unstable as active sand dunes. More generally, there is a sparse cover of vegetation, primarily annuals and ephemerals. For example, a well-riddled slope in drainage A-4 was estimated to have 10 percent cover of vegetation, 5 percent litter, 45 percent erosion pavement, and 40 percent bare ground (fig. 7). The vegetation in this case was primarily tongueleaf violet, pale agoseris, mountain lupine, nodding bluegrass, and bluegrass; the bluegrass was conspicuously pedestaled by a soil remnant.

Figure 6.--Soil movement on 65 percent slope in Snake River tributary A-4. Here, elk trampling, gravity, and oversurface flow of rainfall are factors in serious soil movement.

Figure 7.--Gully pattern at the head of Snake River tributary A-4. Bare soil and extensive rills and gullies indicate very serious rainstorm runoff.

Plant Composition

In many places annuals, particularly Douglas knotweed, were dominant species. Other annuals found were slenderleaf collomia, cluster tarweed, and groundsmoke. On extensive areas, pale agoseris was practically the only plant species seen; the small rosettes were regularly and distantly spaced.

Invasion of Perennials

There is some evidence that perennials are invading such areas. For example, at the head of Gravel Creek, an area with a western exposure about 25 percent steepness, we estimated 35 percent vegetation, 15 percent litter, and 50 percent bare ground. There is a mixture of many newly established perennial plants upon an area dominated by such annuals as Douglas knotweed, with a small amount of slenderleaf collomia. In some other areas we also found considerable tarweed-dominated patches of vegetation. The most strikingly abundant of the grasses is oniongrass.

Other perennials:

thickstem aster	heartleaf arnica	mountain lupine
lappula stickweed	slender wheatgrass	niggerhead
duncecap larkspur	hood sedge	mountain brome
mountain bluebell	lambstongue groundsel	nodding bluegrass
nuttall cinquefoil	pale agoseris	western valerian
	porter ligusticum (loverroot)	

Grasses are generally not very abundant here.

Although invasion of perennial species seems to be progressing on this site and improvement may be expected, in general these same evidences of continuing improvement are not apparent. There is strong reason to suspect also that the already slight invasion of perennials has been stopped and is merely a recurrent thing held in check by the heavy trampling of elk and the workings of pocket gophers.

We found little evidence of the original vegetation on the higher parts of Big Game Ridge because of the severe erosion there. Possibly residual-resistant tufts of ovalhead sedge represent a portion of the original cover (fig. 8). These tough-rooted sedges have so tough a sod that they can resist trampling and exist longer on pedestals of soil than other species can. On

Figure 8.--Sedge on a remnant of soil in Wolverine tributary E-2. Some windblown soil may have accumulated around the plant, but the soil pedestal indicates roughly the amount of soil removed from the surrounding area.

Figure 9.--This herbaceous cover on a west-facing slope in Wolverine tributary E-2, exhibits a very good mixture of grasses and forbs, presumably a remnant of the pristine cover. Counts of droppings, and bed grounds indicated that this area was receiving relatively heavy use by elk at time photograph was taken.

the slopes of the North Fork of Wolverine Creek, we found one stand of vegetation that had been heavily trampled but which strongly resembled the type of vegetation that has been considered pristine in the subalpine zone of the Wasatch Plateau (fig. 9) (1). The exposure was southwest; the slope was rather steep, averaging perhaps 50 percent. On areas little disturbed by elk trampling, cover was as follows: about 65 percent vegetation, 20 percent litter, and 15 percent bare ground. Mountain bluebell and duncecap larkspur were dominant species. Other conspicuous species included lambstongue groundsel, mountain brome, slender wheatgrass, hood sedge, thickstem aster, yarrow, mountain lupine, Engelmann aster, one-flower helianthella, sticky geranium, Porter ligusticum (loverroot), sweetanise, pedicularis, and arnica.

It may seem incredible that such lush, dense vegetation once dominated the open parklike uplands of Big Game Ridge, for no evidence of this can be seen now. However, these species have been found growing in equally exposed situations in the subalpine zone of the Wasatch Plateau.

Probably, if a detailed ecological study is ever made of Big Game Ridge and similar ridges in the Teton Wilderness Area, the foregoing list would provide a fair approximation to the pristine vegetation of this subalpine country.

Invasion of Trees

Around the edges of most limber pine stands, there is evidence of invasion of the eroded soils by young trees. Had former timber stands been burned so that the sites were known to have been timber sites, this would not be remarkable; but since these trees are invading former herbland, the process constitutes strong evidence of disturbance of the herbland soil. From the study of subalpine vegetation of the Wasatch Plateau referred to above, it has been concluded that in certain situations, herbland is climax but in others, forest is climax. There is some succession between the two, but the trend under natural conditions is from forest to herbland and not (as is popularly supposed from experience in the East) from herbland to forest.

Trampling Displacement of Soil

Widespread pounding and churning of the soil by the hoofs of elk is recorded everywhere. Much of this trampling evidently is done while the ground is wet; it is a probable consequence that many perennials are killed while a habitat is being provided for annuals (fig. 10). Another example of trampling displacement of soil is found on a steep, stony eastern exposure on the east side of Big Game Ridge (fig. 11). Since this area is practically free of pocket gophers, they contribute very little to the soil disturbance; but the soil is heavily trampled by elk and the downward displacement of soil is obvious. On steeper slopes, the perennial grasses have been overturned so that the shoots are growing out parallel to the slope, and the downward displacement is otherwise evidenced by stones on plants. In a fairly representative spot on this slope, we estimated that there was 40 percent rock, 50 percent bare ground, 5 percent litter, and 5 percent plants. On the gentler portions of this slope, the plants are markedly pedestaled.

Soil Remnants

In general, pedestaled plants are neither as common nor as widespread on this range as on other deteriorated subalpine ranges with which we are familiar. This is probably because the extreme amount of trampling here destroys the pedestals (soil remnants on which plants are perched). A most commonly observed pedestaled plant is hood sedge. The tough sods evidently resist trampling. In cutting through these pedestals to separate the portion above the root crown from the pedestal proper underlying it, one can commonly find an indication that 2, 3, or even 4 inches of soil has been washed away (fig. 8). It is not at all clear, and cannot be clear without further study, whether these pedestals represent the original soil surface or whether these sedges have become established on an eroded surface.

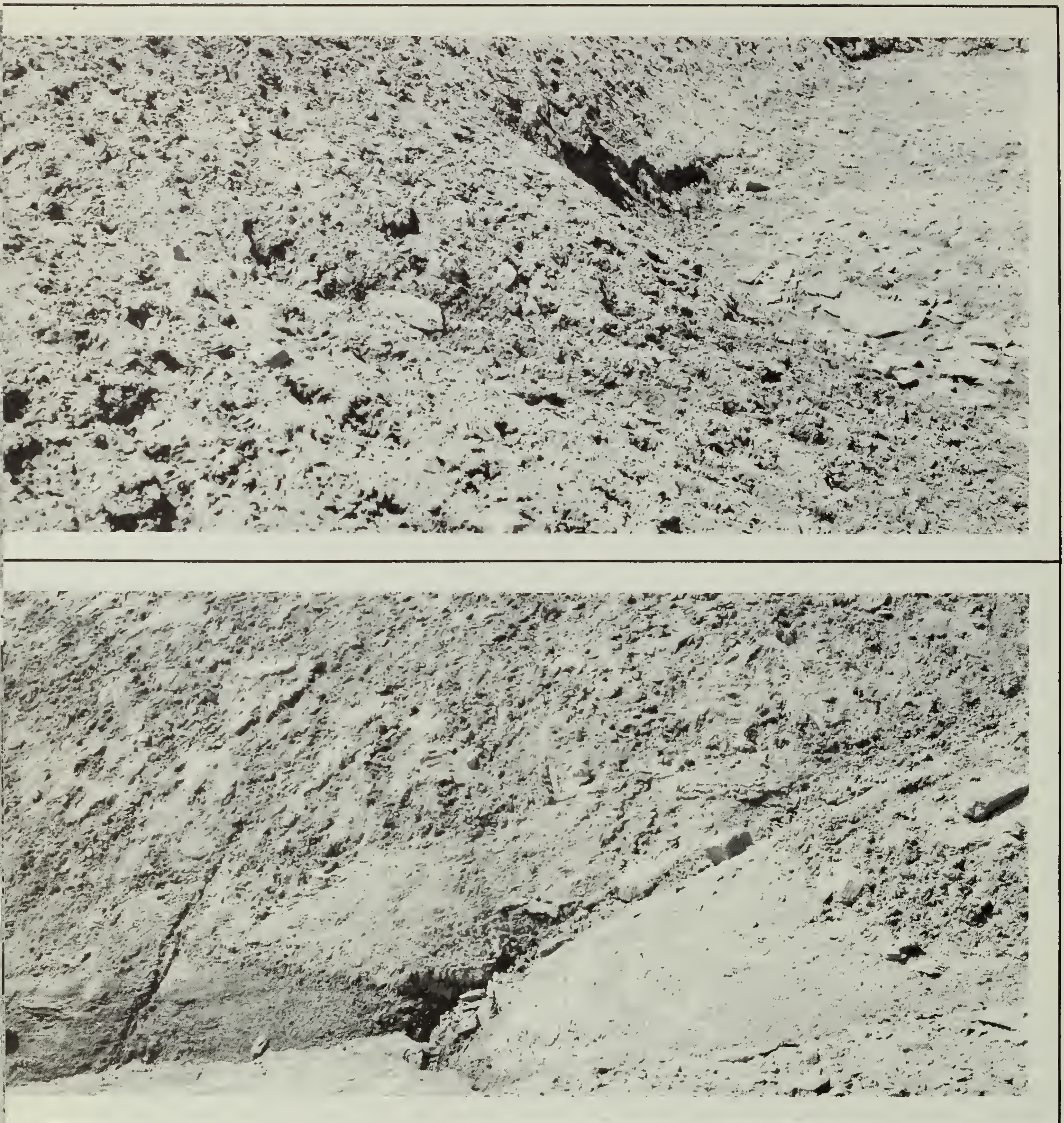

Figure 10.--These steep eroded gully slopes show the manner in which elk disturb the soil. Presumably the trampling begins while the gully is completely filled with snow and only the ridgetops are showing. The elk work along the contact line between the steep slope and top of snow deposit, cropping the sedges as they are exposed by snow melting. This process continues until the snowpack has completely melted from the gully; this leaves the slopes in a much puddled and pockmarked condition.

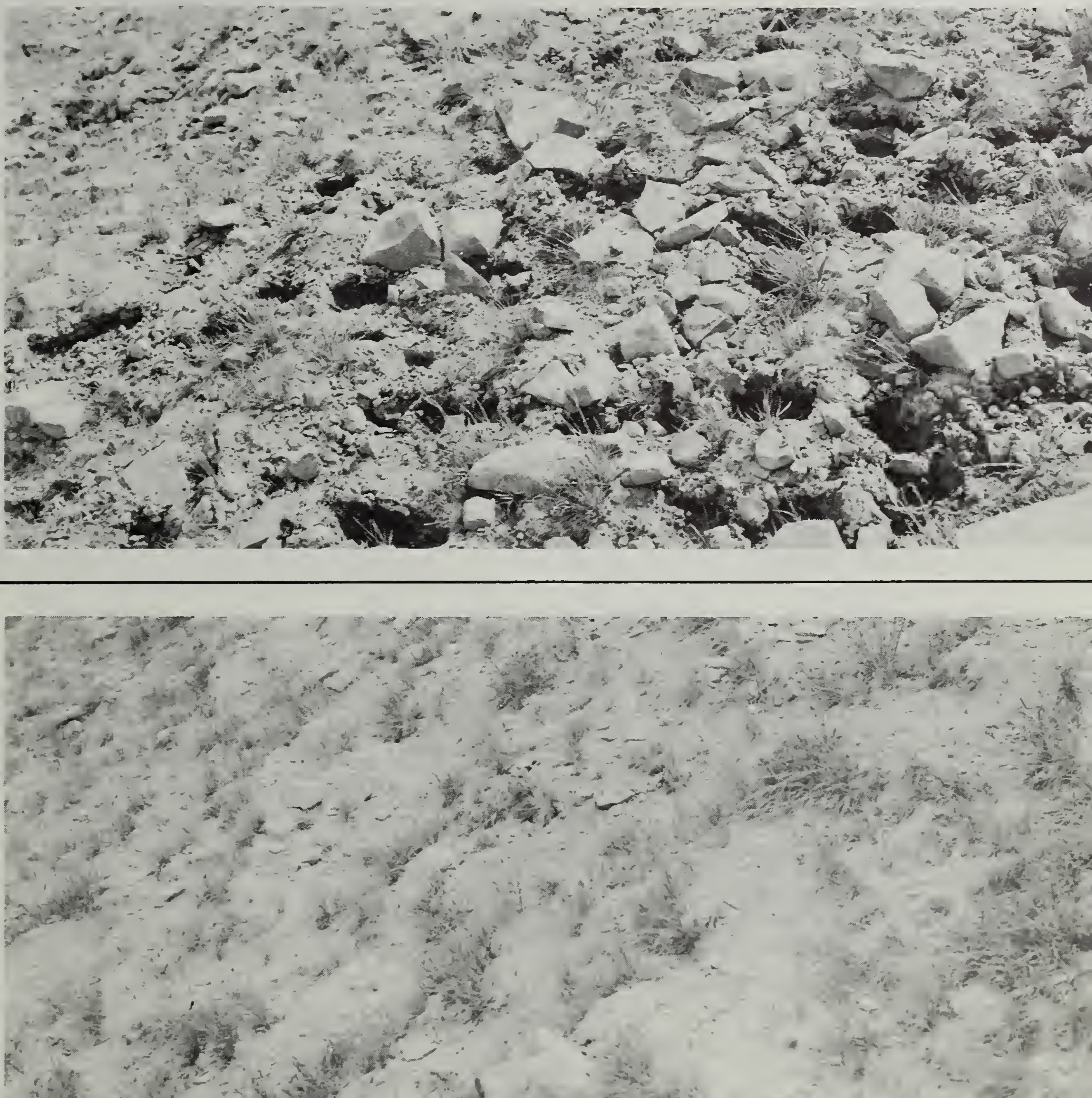

Figure 11.--Northeast-facing rocky slopes in Snake River tributary C-2, which is typical of the general condition of soil and plant cover in the area. In the upper photograph note the deep footprints made by elk while the ground was wet. (Bottom) A thin film of water-washed mineral matter which has moved down over the darker soil beneath. About the only vegetation is scattered decadent grasses and sedges.

Erosion Pavement

On slopes of even a moderate degree of steepness, erosion pavement is common. On several slopes we found where soil had been eroded down to bedrock; but most commonly erosion pavement, in the form either of sandstone fragments or fragments of volcanic rock, is the most frequent evidence of soil deterioration (fig. 12).

Figure 12.--Erosion pavement on east-facing slope in Snake River tributary A.

Active Gullies and Alluvial Deposits

Gullies are very common and they enlarge as they descend the canyons. Widespread deposits of flood rock are present on sides of the canyons and where the gradient lessens at the canyon mouths (fig. 13). Local flood deposits from smaller gullies can be found on the watershed wherever the gradient of the slope lessens. Rills are scarce; most obvious development was in

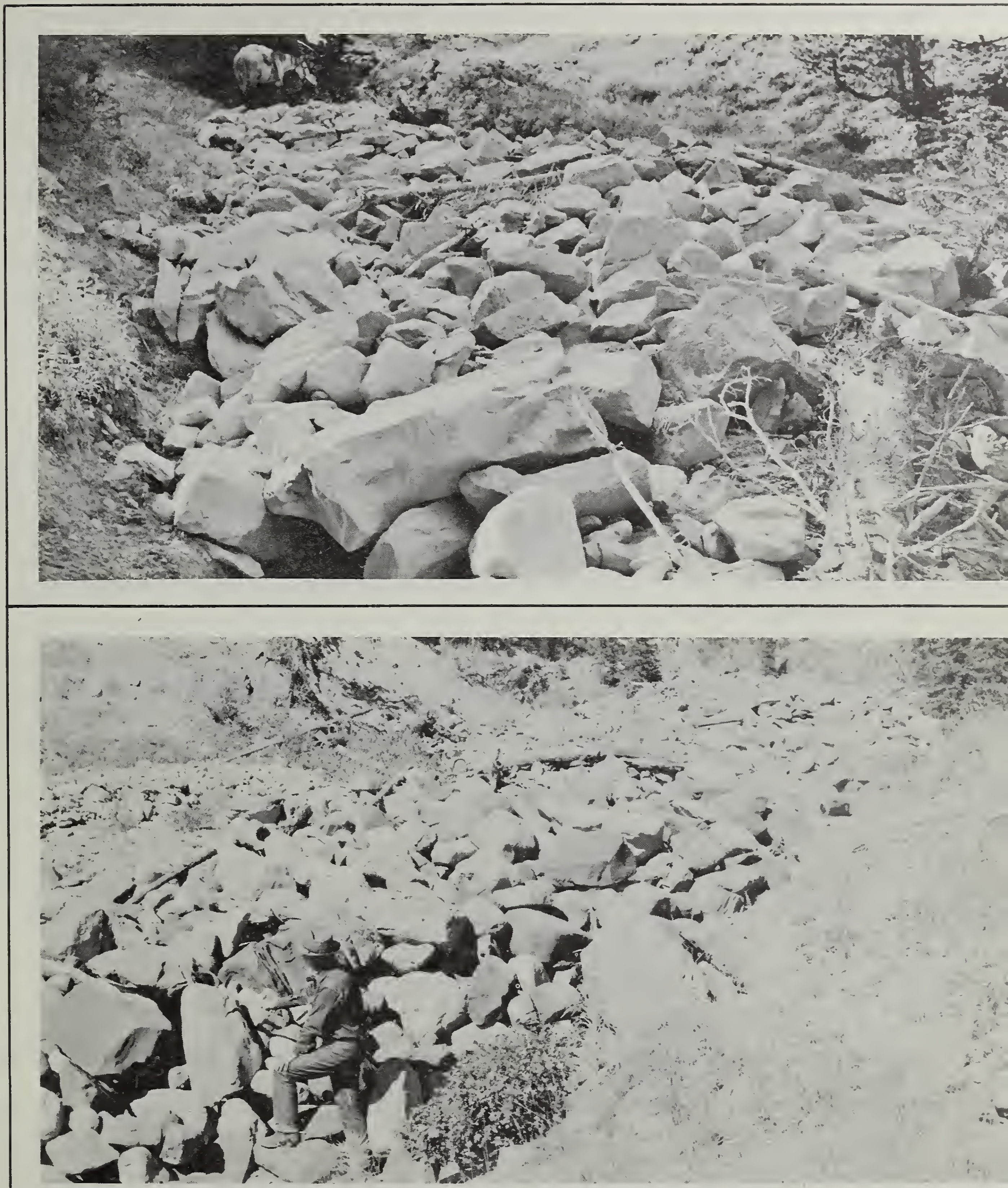

Figure 13.--Boulders deposited by floods in lower reaches of Wolverine tributaries D and E.

the head of drainage A-4, on an easterly exposure (fig. 7). Apparently erosion had not gone as far on this site as on warmer westerly and southerly exposures because the elk had not concentrated on the cooler easterly slopes in the numbers or at the time of year that they have on the warmer exposures.

Exposed roots of limber pine at the heads of some gullies indicated the amount of soil materials that had washed away since the trees became established. In some locations this amounts to as much as 2 or 3 feet of soil materials that have been either blown or washed away (see cover).

It may be reasonably assumed that most of the topsoil on the slopes of Big Game Ridge has eroded, leaving an erosion pavement or a sandy, rocky subsoil. In the head of Wolverine Creek on the trail from Gravel Creek to Big Game Ridge, we found a meadow cut by a new gully. Near the head of Gravel Creek we observed meadows being covered by sediment flow (fig. 14).

Farther along the trail in the head of Wolverine Creek we found a series of mud-rock flows that have stopped in timber (figs. 15 and 16). The most recent one is probably less than 5 years old; part of it is blocked by a down spruce with the bark still on. Vegetation on this deposit is primarily horsetail rush. The following perennials appear to have come in shortly after the flood: slender wheatgrass, nodding bluegrass, yarrow, bluebell, dandelion, and groundsel. On a much older flow, we found a spruce 50 inches high with 40 growth rings. On an intermediate flow, we found a spruce 34 inches high with 20 growth layers.

On August 19 we examined the ridge above these flows. The basins have been depleted of practically all vegetation, and consist of very sandy subsoil with very sparse or no plant cover (fig. 17). Channel fill has been scoured out and the bedrock is now exposed in the bottoms (figs. 18 and 19). Slopes of channels are very deep and are eroded (fig. 20).

Wind-scoured Depressions and Aeolian Deposits

Some evidence of wind scouring can be seen at the tops of ridges, particularly between clumps of limber pine. These depressions have the appearance of sandy blowouts. Some deposition of soil appears to take place in the trees and currant bushes with which the patches are fringed.

Evidence of Depletion in Valleys

The meadows, such as Fox Park, show considerable evidence of trampling disturbance. Even the wet meadows are so heavily trampled by elk that one can hardly put his hat down without covering one or more tracks. In general, however, the very tough sod of the meadows strongly resists damage so that the cover of vegetation is still very good; it consists mainly of tufted hairgrass, with considerable meadow barley, Kentucky bluegrass, slender wheatgrass, sedge (meadow), thickstem aster, and many other species (fig. 3). There is a mossy ground layer. In very wet places a reedgrass is conspicuous and grows densely.

Figure 14.--Sedge meadow partly covered by sediment from a tributary of Gravel Creek.

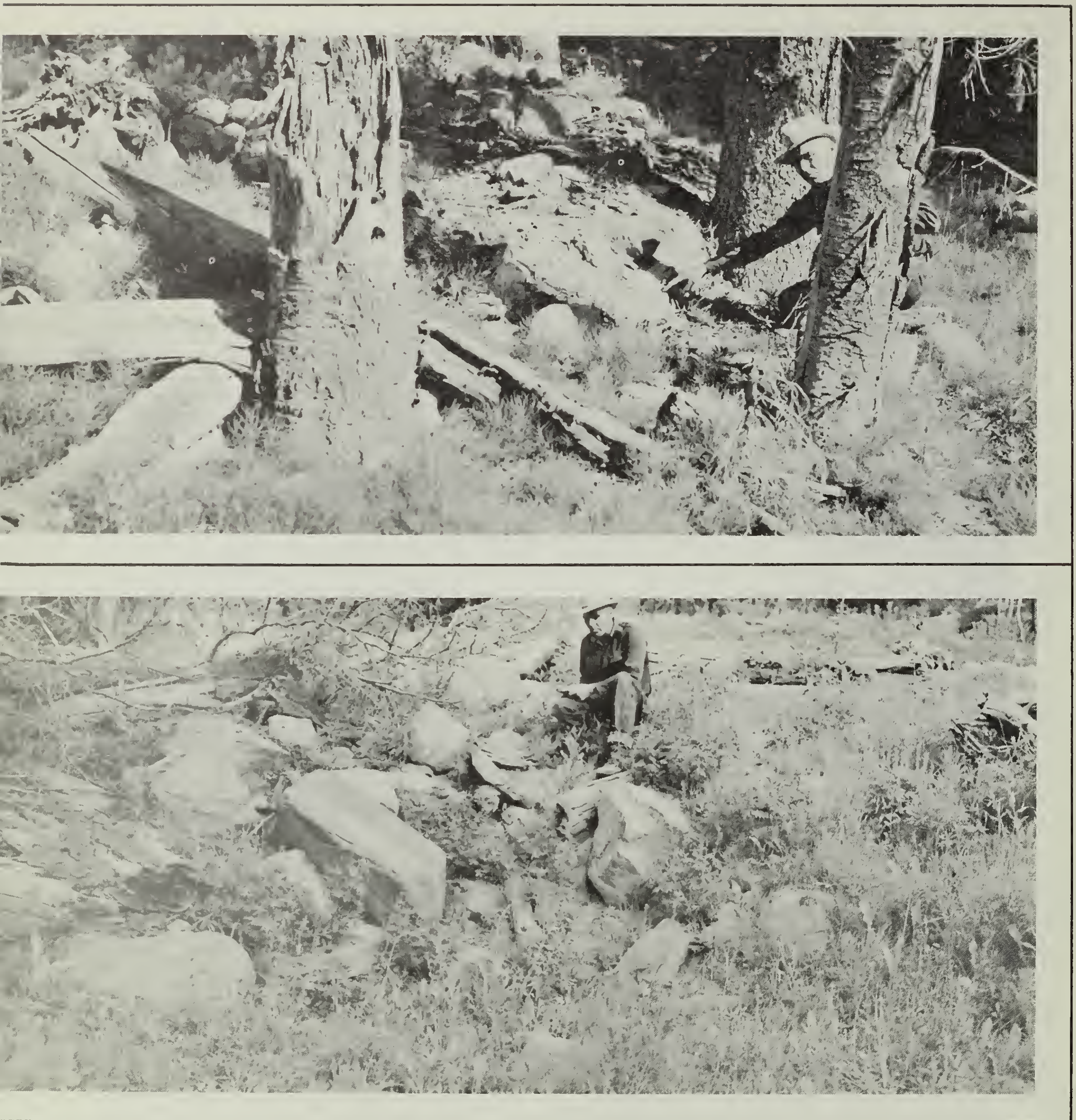

Figure 15.--Mud-rock flow deposits near where the trail crosses the head of Wolverine tributary G-2. Floods occurred probably 40 or 50 years ago as judged by the age of small spruce trees that have become established on the deposits.

Figure 16.--Mud-rock flows in the head of Wolverine tributary G-1 near those shown in figure 15. Note the layer of light mineral matter that has been deposited over the very old weathered topsoil (upper). The bottom photo shows a flow probably less than 10 years old, which has been deposited on top of older flows.

Figure 17.--Sparse vegetal cover, very largely annual weeds with a few scattered herbaceous shrubs, and bare soil in the head of Wolverine tributary G-2 above mud-rock flows shown in figure 15. The ridge in the background divides upper Wolverine drainage from the head of Snake River drainage approximately 4 miles south from the south boundary of Yellowstone National Park.

Figure 18.--Channel erosion about 400 feet downslope from location shown in figure 17.

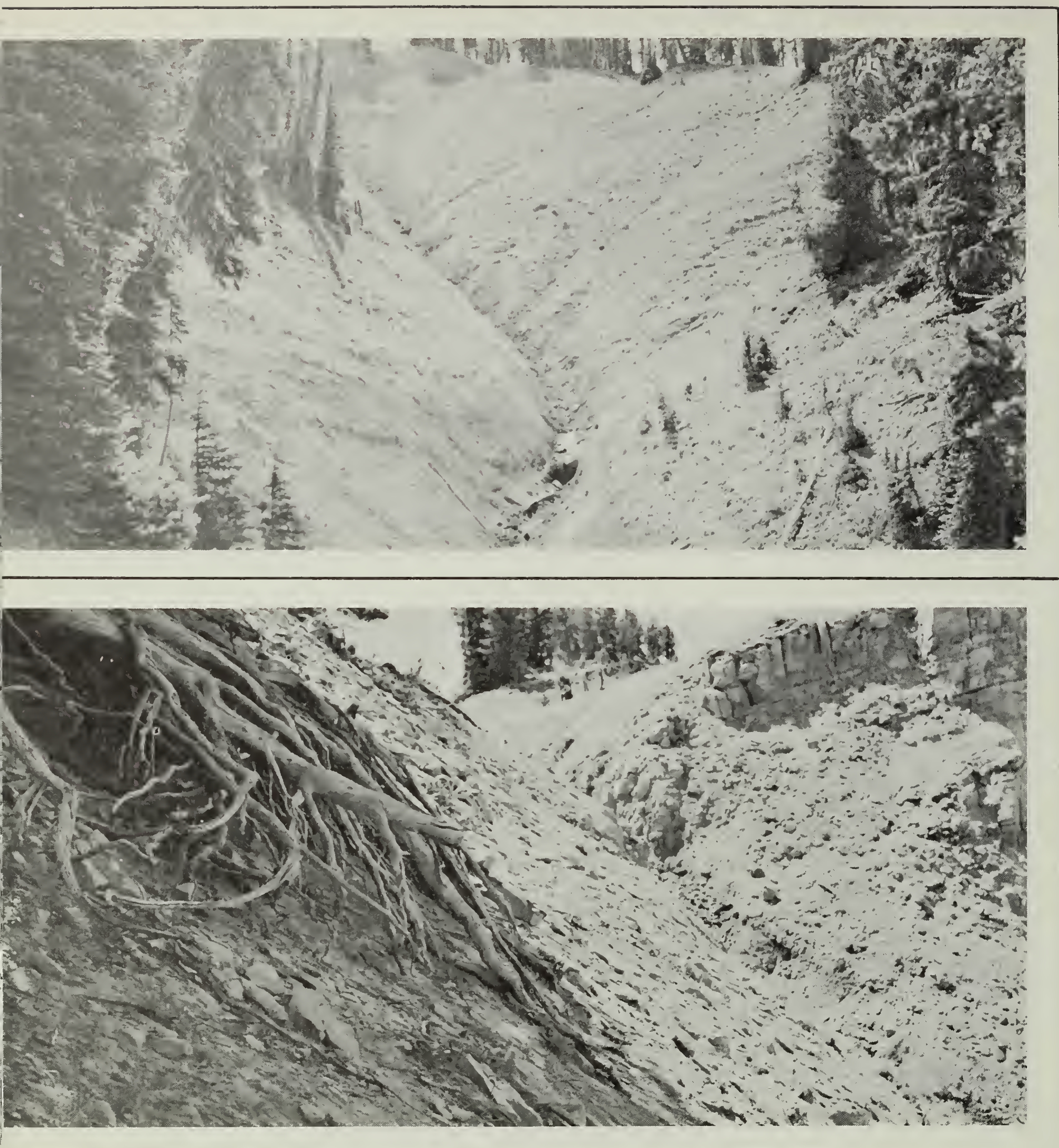

Figure 19.--Channel erosion in the head of Wolverine Creek, about 1,000 feet downstream from location shown in figure 18.

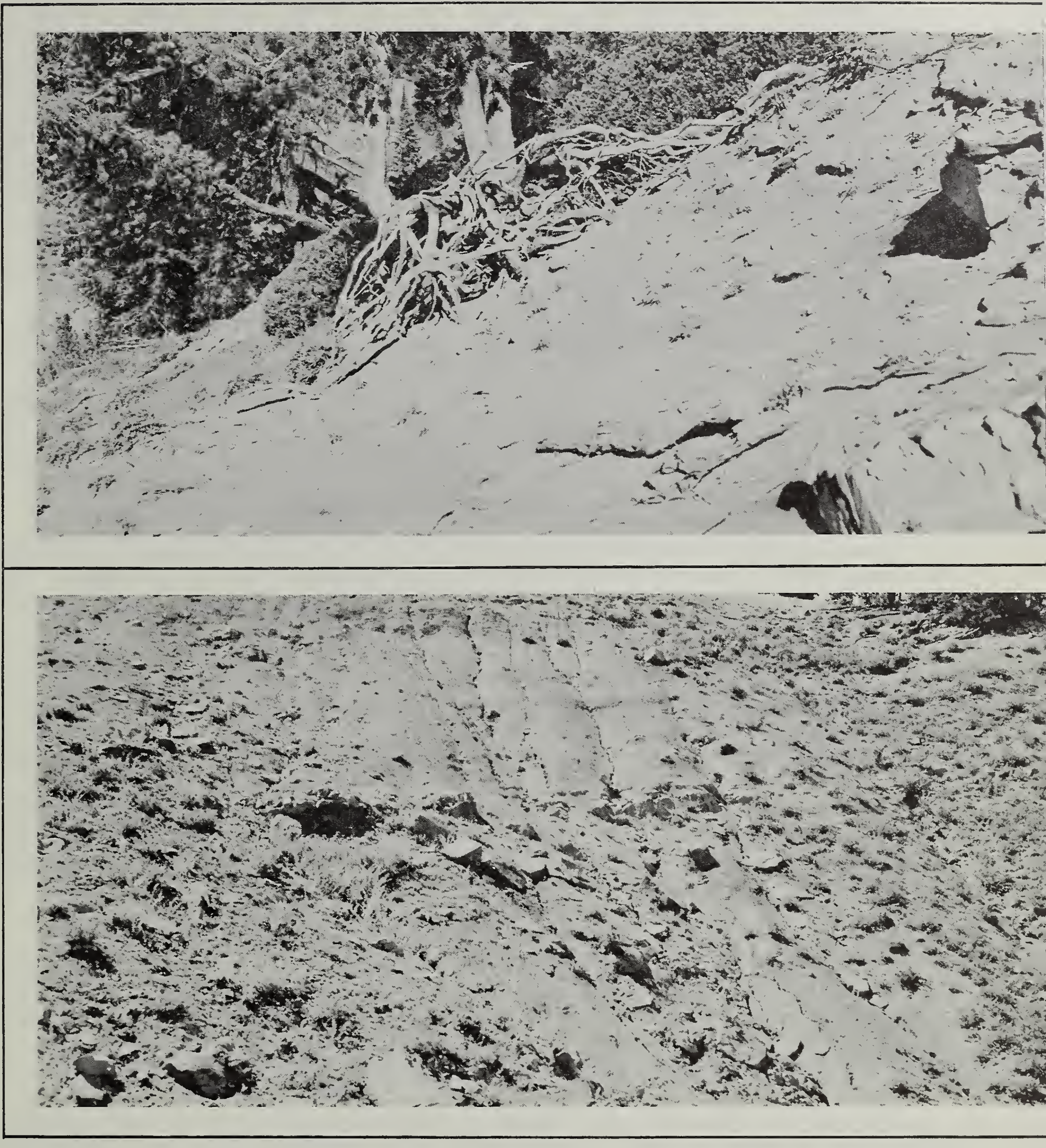

Figure 20.--Channel wall of Wolverine Creek near location shown in figure 19. The lower photograph is a closeup of sidehill on the north of the drainage. Soil remnants are relatively deep and black, suggesting a long stable deposit.

Evidence of deterioration is marked on the lower, drier slopes fringing the valleys, and on knolls and ridges within the valley. On these knolls and ridges, Idaho fescue is dominant in a mixture of many species. A considerable portion of this area is bare soil or erosion pavement. Some areas are dominated by annual plants, mainly Douglas knotweed, and have been much disturbed by pocket gophers. On the tops of some knolls and their slopes, as much as 70 percent of the surface is bare ground and rock. In other places pussytoes and selaginella have occupied the formerly bare spaces to favor a vegetal and litter cover as much as 90 percent.

The open slopes through which the trail to Big Game Ridge climbs out of Fox Park serve as an example (fig. 21). The openings are dominated by annuals, primarily Douglas knotweed, but also include cluster tarweed and groundsmoke. The scattered perennials consist mainly of cinquefoil, wheatgrass, and dandelion. Occasional clumps of sedge suggest these were once rather wet sites. There is a great deal of soil disturbance, both by trampling of elk and by winter and summer burrowing of pocket gophers. This type of cover and evidence of disturbance apply fairly well to the open slopes in the mountain forest zone, despite the fact that some meadows in the depressions have heavy cover of grasses, sedges, and forbs (fig. 22).

On the knolls and drier flats the grasses tend to be somewhat pedestaled, and large rocks often show lichen lines that indicate loss of an inch or two of soil. The pedestals alternate with bare depressions between the plants.

Just below the Dietrich camp, southwest of the Snake River crossing, we found a flat that was especially depleted of perennial vegetation but which had an abundance of annuals. This area had provided pasture for 30 to 50 horses for a week to 2 months during the hunting season. Just above this flat a raw channel that heads on Big Game Ridge shows much bank cutting (fig. 23). Some of the depleted basins leading into this channel, like the others in this high country, had little cover except abundant annuals. Many rills, gullies, and pedestaled plants were present. In contrast to this heavily used area, the Snake River valley bottom upstream and the stream channel show remarkably stable near-pristine conditions (fig. 24).

Around meadows (Fox Park) young lodgepole pine have invaded around margins of lodgepole stands on knolls and ridges. Many of these slopes are steep and bear marks of accelerated erosion--erosion pavement and broken sod with exposed roots. Depletion of herb cover of these slopes may have accelerated the spread of lodgepole. It is doubtful that many of these little lodgepole trees will survive.

On many of these knolls, lodgepole is attempting invasion, but a high proportion is dying or dead. Some young trees probably have been hindered by browsing or by elk polishing their horns.

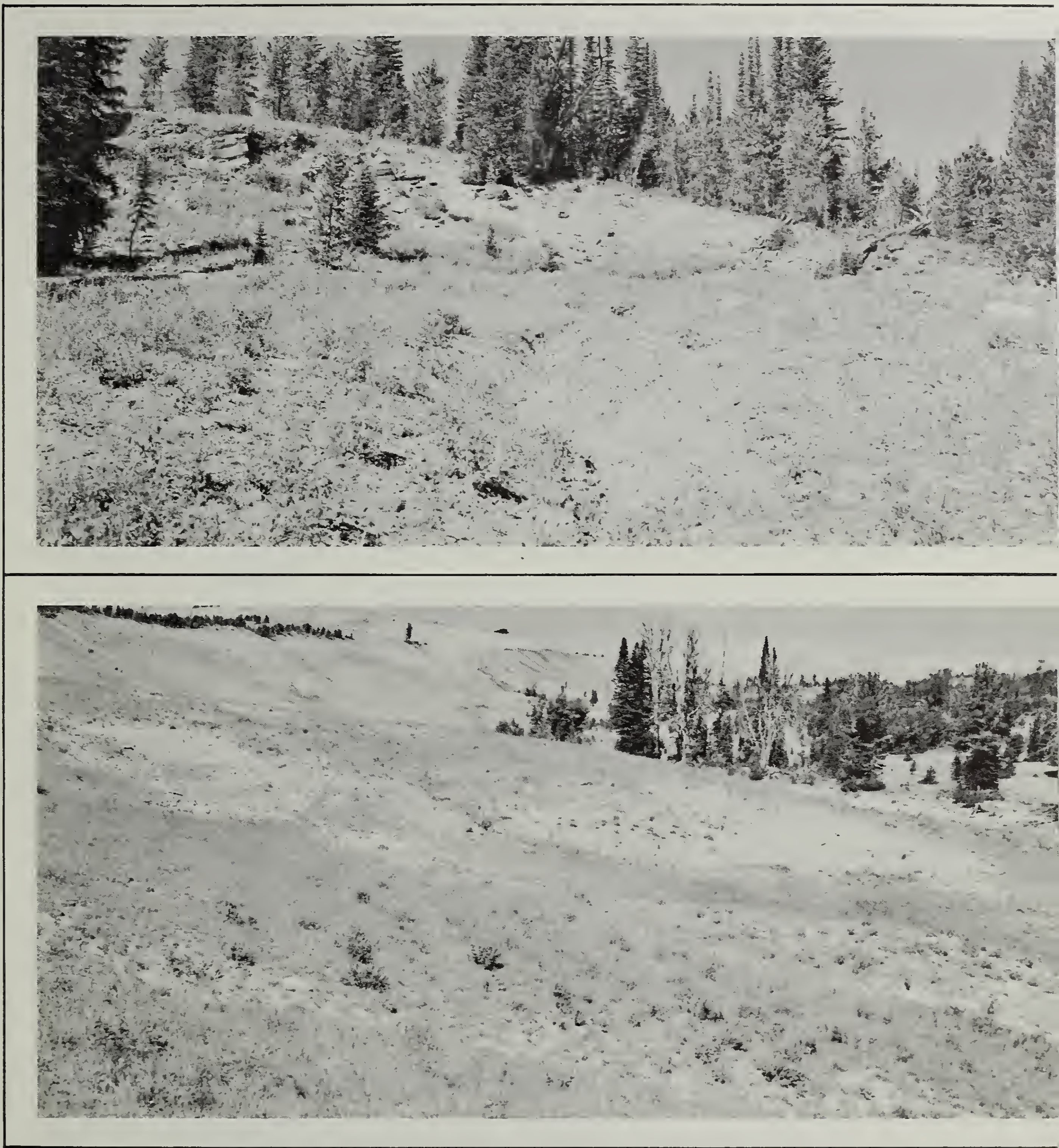

Figure 21.--Open slopes along the trail to Big Game Ridge west of Fox Park are dominated by annuals with only a scattering of perennial plants.

Figure 22.--A small hillside meadow in good condition adjacent to badly depleted east-facing slope along trail west of Fox Park, in Snake River drainage C-4.

FLOOD DAMAGE FROM WATERSHED DETERIORATION

Our appraisal of flood damage depends on how "flood" is defined. For example, torrential rains on only a few square feet of bare soil result in small oversurface "floods" that erode the soil. The small rivulets that form on these areas, in turn, join others to produce larger volumes of water, which cut gullies into the soil (fig. 7). Gullies funnel their water into small channels that may be either eroded or damaged by boulder deposits (fig. 13). As this process continues downstream, channels become choked with timber and boulders (fig. 25). Many tributaries of the Upper Snake River and Wolverine Creek have suffered this sort of damage. Once productive trout streams have been so severely damaged as to be almost useless for spawning or habitat.

Serious mud-rock flows have damaged subdrainages 1 and 2 of tributary G of Wolverine Creek (figs. 15 and 16).

Figure 23.--Snake River tributary F at the point where it joins the main stream which is shown in figure 24.

Figure 24.--Near-pristine conditions in the Snake River channel and valley bottom just upstream from tributary F, shown in figure 23.

Figure 25.--Channels choked with boulders and logs as a result of concentration of oversurface flow from numerous small bare areas on watershed above.

Figure 26.--Channel of Pacific Creek immediately below confluence with Gravel Creek. Remnants of soil and plants suggest that pristine valley bottom was comparable to that shown in figure 27.

Figure 27.--Valley bottom of Upper Pacific Creek drainage through which the stream meanders. At some time in the immediate past it is probable that most of the Pacific Creek valley bottom had much the same vegetation and soil.

Figure 28.--Scanty vegetation, largely annuals, in the general vicinity of the headwaters of Wolverine tributaries D-2 and 3. The elk (about 20) on ridgetop in lower photo are part of a group of 140 head.

Extensive floods have damaged Pacific Creek below its confluence with Gravel Creek (we did not inspect Pacific Creek above this point). They have destroyed extensive meadow areas and have choked the stream channel with gravel (fig. 26). Figure 27 shows the probable natural Pacific Creek Meadows.

CAUSES OF RANGE-WATERSHED DETERIORATION

We understand that no cattle or sheep have ever been grazed in the Big Game Ridge Area. Although cattle do graze in the southern end of the wilderness area, none graze in this portion, and there is no evidence of their past presence. Saddle and pack animals create a local problem in the flat below Dietrich camp, as mentioned above. However, when compared with the existing widespread deterioration, this local damage is not serious.

Evidence of Elk Damage

The most clear-cut evidence of elk damage is the trampling already reported. There appears to be hardly a square foot in this country that is not trampled once, or more frequently, each season by elk. Indeed, trampling appears to be the most serious effect that elk have on the range, because, while their utilization of the vegetation is evident, it is by no means so complete as one would expect from the vast number of their tracks.

On August 22, we visited an area where we had seen elk feeding 2 days before (fig. 28). The vegetation here was very scattered, and most of the ground was bare. The species utilized especially heavily were thickstem aster and Pseudocymopterus, each probably to an average of 70 percent. Elk also readily take pale agoseris. In fact, they take a little of everything, including nodding bluegrass, mountain lupine, tongueleaf violet, western yarrow, slender wheatgrass, and Bear River fleabane. In this particular area it was clear that elk had also grazed earlier this year, both from the evidence of old tracks and prior utilization. Probably, in the present depleted state of the vegetation, the amount of utilization of it made by elk is harmful. On the other hand, if the area were supporting a vegetation of which it is capable a much larger amount of forage would be available with considerably less proportionate use of the plants. This would be tolerable, providing the seasonlong repeated trampling could be avoided.

Other evidence of the influence of elk on vegetation is the barking of saplings and young trees by elk polishing their horns and the close cropping of willows in many places.

Evidence of Pocket Gopher Damage

In most open places, we found winter cores and summer mounds made by pocket gophers (fig. 29). The presence of pocket gophers is considerably less evident than the presence of elk. Gopher workings were not found in dense timber or in very wet meadow soils, and only to a minor extent in rocky soils. The extent to which pocket gophers throw up mounds as a result of the elks' trampling and breaking through their burrows was not ascertained, but it has been observed in other places that trampling by sheep does stimulate pocket gopher activity. Possibly some of the summer activity we saw was stimulated by destruction of burrows by trampling of elk.

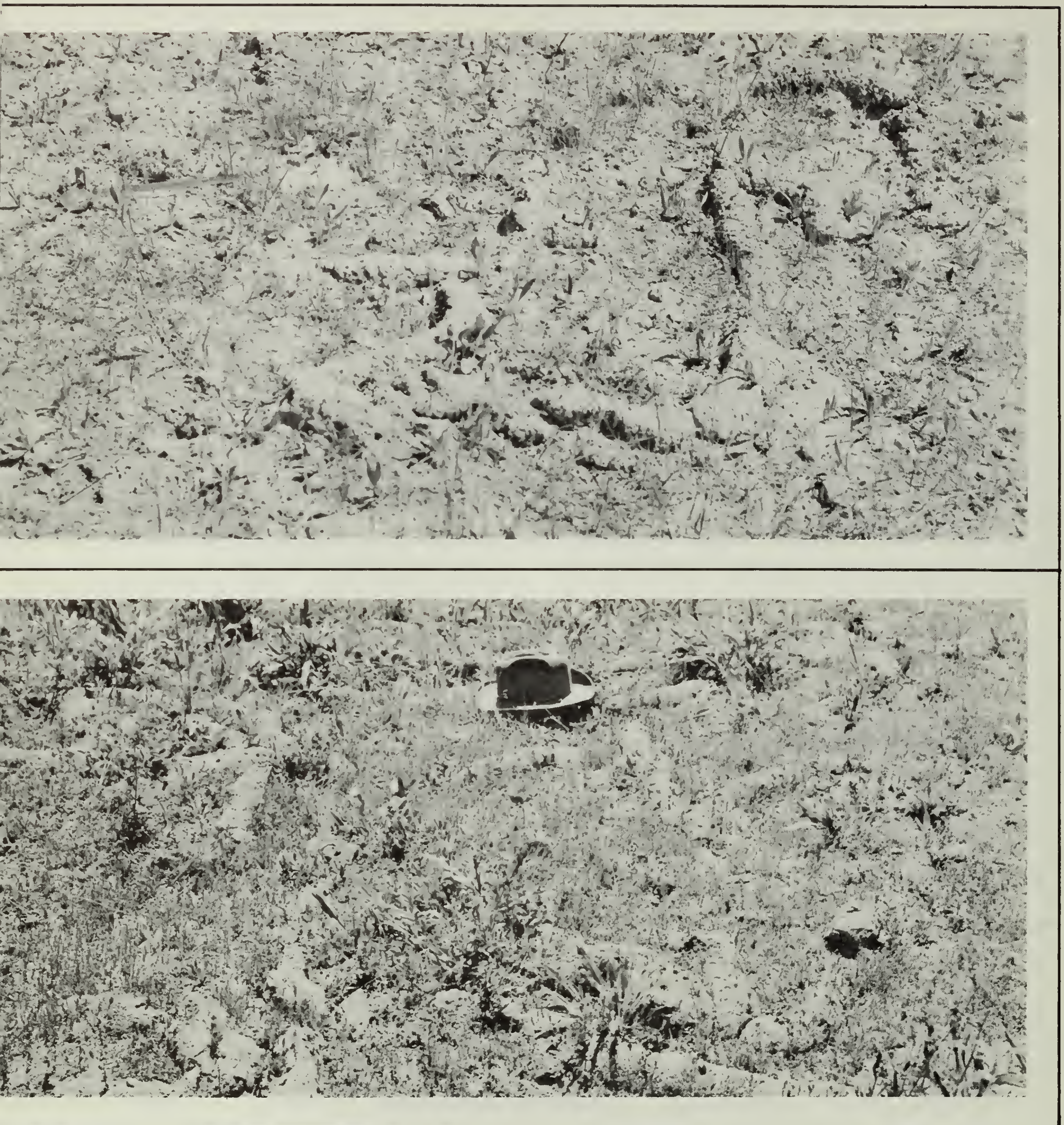

Figure 29.--Winter gopher castings on a depleted game range dominated by annuals in Wolverine tributary D-1.

Evidence of Fire Damage

Throughout this country, we found evidence of fire. The Mink Creek burn (1937) was very conspicuous. A portion of this, which we saw in Gravel Creek, had a fairly heavy cover of grasses, sedges, and shrubs, and young trees, but gave no evidence of having been the source of the flood deposits we saw.

Evidently the limber pine on Big Game Ridge, now 10 to 15 feet high, has come in following a rather extensive burn probably about 1885. Most of the trees are growing near the bases of burned snags (fig. 30). One ring count to the pith on a 3½-inch tree gave 70 rings. An estimate on a 6-inch tree, on the basis of a 1-inch cut, gave 60 rings. It might be argued that such an extensive fire could have burned only if there had been a much greater ground cover than exists now, because no such extensive fire could be carried by the present scanty vegetation on the ground.

Discussion

Everywhere we visited on Big Game Ridge the deterioration of grazable vegetation and soil erosion were glaringly evident. Since the area is not grazed by livestock, we would look to such agents as fire, rodents, or grazing by elk as causes of its present poor condition.

Evidence of accelerated erosion are entirely too recent, too active, and too widespread to be accounted for by old fires. We know of areas where fires, closely followed by torrential storms, have given rise to accelerated runoff and mud-rock flows. However, this circumstance is very rare and depends upon the coincidence of the fire and the storm. Let us suppose, for example, that the average timber stand burns over once in a hundred years and that from the standpoint of storm intensity, we are thinking of the 10-year storm. The probability of coincidence is then $\frac{1}{100} \times \frac{1}{10} = \frac{1}{1,000}$, obviously very small. Accordingly, fires can be dismissed from consideration in the problem area we are considering.

The question of particular interest is the relative effects of pocket gophers and elk in causing the observed deterioration of vegetation and soil. Because we have no completely objective experimental proof on Big Game Ridge, this question must be answered by inference and by what we know of the factors of soil formation and accelerated soil erosion elsewhere.

Pocket gophers might conceivably have caused the observed deterioration of vegetation and soil on Big Game Ridge in two ways. One is by baring so much soil and creating so many tunnels as to accelerate erosion directly. The second is by destroying the vegetation and leaving the soil unprotected. These processes have been treated in detail in the subalpine zone on the Wasatch Plateau (2). Here, it is pointed out that before the tunnels can channel water, a collecting surface must be developed, and that this collecting surface has been observed most commonly to be bared and trampled soil on overgrazed range. As for destruction of vegetation, this paper points out that a natural area, essentially undisturbed by grazing animals, appears to have about as many pocket gopher mounds as nearby grazed range, and yet the perennial cover on them is dense enough to prevent accelerated erosion.

Figure 30.--Remains of limber pine tree in head of Wolverine tributary D-4. Ring counts of young trees suggest that the tree was in a grove killed by fire about 1885.

On Big Game Ridge, we found several areas of dense vegetation that had many gopher workings in them, though it was impossible to say whether they had more or fewer pocket gophers per unit area than the adjacent depleted range. Many eroded areas, from 1 square rod to several square rods in extent, now support no pocket gophers so far as could be ascertained; yet annual plants are abundant on these areas, and the soil is eroding rapidly. Obviously, therefore, pocket gophers are not contributing to the current erosion--although it might be argued that they caused enough erosion to deteriorate the site and then moved out.

In the subalpine zone of the Wasatch Plateau at the head of Ephraim Canyon, a study of pocket gophers continued for 10 years (prior to 1955); in one portion, an area was kept free of pocket gophers by trapping, but the adjacent ground was free for pocket gopher invasion (3). These pocket gophers exerted very little influence on the vegetation. Photographs in this publication showed the division line between the area occupied by gophers and those free of them. The similarity of this Wasatch Plateau country to Big

Game Ridge is evident. There is no evidence of greater erosion on the area populated by pocket gophers than on the areas from which they were excluded. Actually it is reasonable to infer that the infiltration capacity of the soil is much greater (and accordingly less destructive over surface flow of water) where gophers are present than where they are absent, because the soil where gophers are present is much looser and softer then where gophers are absent. One can detect the difference merely by walking across the area.

Adjacent areas show evidence of accelerated erosion on range grazed by sheep, whether pocket gophers have been removed or are present.

A study in eastern Oregon, however, has shown that pocket gophers markedly retard the establishment of perennials on depleted mountain meadows (4). Although results of these two studies may seem contradictory, it appears that the influence of pocket gophers on vegetation of range that is very greatly deteriorated is probably much more pronounced than on range where the deterioration has not gone so far.

These earlier studies, therefore, can be reconciled by summing up our present state of knowledge as follows: The pocket gopher is a normal factor in the soil-forming process of well-drained mountain soils. Through his contributions to creep of the soil mantle, the gopher is a geologic agent in normal soil erosion. Under such conditions, the gopher does not create what we widely see on western mountain ranges as accelerated erosion. On heavily grazed and trampled range, however, the pocket gopher can and does add both to depletion of vegetation and to acceleration of soil erosion. Thus, the pocket gopher is an agent both in geologic normal and in accelerated erosion. However, the pocket gopher is not the primary cause of accelerated erosion that is commonly associated with depletion of plant cover by overgrazing. Accordingly, on Big Game Ridge, we regard the pocket gopher at most as a very minor factor in the deterioration of vegetation and soil erosion.

The only other important influence is grazing by elk. We believe, in view of the evidence observed, that the destruction of vegetation and soil on that part of Big Game Ridge that is the object of this report is largely a result of excessively heavy use by elk. Apparently much use occurs in the spring when only the windswept ridges are free of snow and before any notable plant growth has occurred.

Probably any material fraction of the present herd would continue the damage that is already well along, because they would continue to trample the same sore spots at about the same seasons of the year.

RECOMMENDATIONS

1. As a preliminary to effecting needed adjustments in use, the people and agencies involved must be informed of the conditions in the range watersheds where the elk obtain all but a small part of their food supply. This can be done on the basis of what is now known.

2. At the same time tests must be made to determine practicable methods of stabilizing the soil, restoring vegetal cover, and controlling streamflow. The exclosures now being planned are a beginning. Tests should also be made of such artificial measures as seeding and, if necessary, contour trenching. Experience elsewhere shows that some of these deteriorated sites are entirely too harsh to be restored simply by natural means; hence we must emphasize that the tests should not be limited by what seems to be <u>practical</u> expediency at present. The effort should be made, rather, to determine whether a plant cover can be restored by <u>any</u> means.

3. A detailed study of soils and vegetation is needed for proper appraisal of the potentialities of the Big Game Ridge watershed. Such a study would require at least 1 year's work by an ecologist well trained in ecology of western mountain range watershed lands and familiar with range watershed conditions elsewhere in the West. Gathering evidence for an actual reconstruction of the pristine vegetation and soil is made difficult by the fact that few open ridgetops are likely to be found that are not currently being heavily grazed and trampled by elk. Such a study would require extensive travel in the wilderness area. The effects of elk grazing on soil and vegetation need to be examined on the ground at all times of the year, especially in early spring, when travel is likely to be slow and difficult.

4. An investigation of the movements and distribution of elk during the seasons of the year when they are on their summer range is also needed. Such observations have been started by the Wyoming State Department of Game and Fish and need to be intensified to give more accurate ideas of (1) numbers that graze various areas on the range and (2) the times these areas are occupied. A critical season, from the standpoint of range conditions, is when the soil is wet during and immediately following snowmelt. Another critical time, from the standpoint of control of numbers of elk is the hunting season.

5. The food habits of elk need to be studied, and a relative amount of trampling occasioned in grazing and other activities need to be more clearly recorded. Our reason for emphasizing this point is that despite several years of observation and familiarity with the elk in this area, an official of the Wyoming State Department of Game and Fish feels quite unable to give an estimate of the relative intensity of seasonal use of these open herblands. He feels quite sure that the elk trail them heavily while the ground is wet. We have observed evidence of this. However, the question remains: What are the effects on the range of such transient trailing, and what is the effect of the resident herd?

6. Another problem involves determining the normal population of pocket gophers and whether the plant species that are abundant on depleted range encourage large populations of these animals. Techniques for determining the comparative intensity of use of ranges by both elk and pocket gophers need to be improved. These studies do not necessarily need to be carried out on Big Game Ridge. Principles developed from such studies on areas easily accessible to research workers can be applied to Big Game Ridge.

7. The hydrologic and ecologic effects of pocket gophers on rangeland need to be clarified further. Any study undertaken should include the effects of elk trampling on infiltration of summer rainstorms and snowmelt, and on accelerated soil erosion. There are reasons for thinking that under fairly good plant cover conditions, pocket gopher workings may be beneficial in terms of soil formation and vegetal development; whereas on depleted range the influence of pocket gophers is probably destructive. At any rate, the problem needs further study.

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